



# Robotic Technologies for the Future Force – The ART ATO



SUPERIOR TECHNOLOGY

**Jeffrey F. Jaster**

ART Development Team Leader

Intelligent Systems

(586) 574-5106

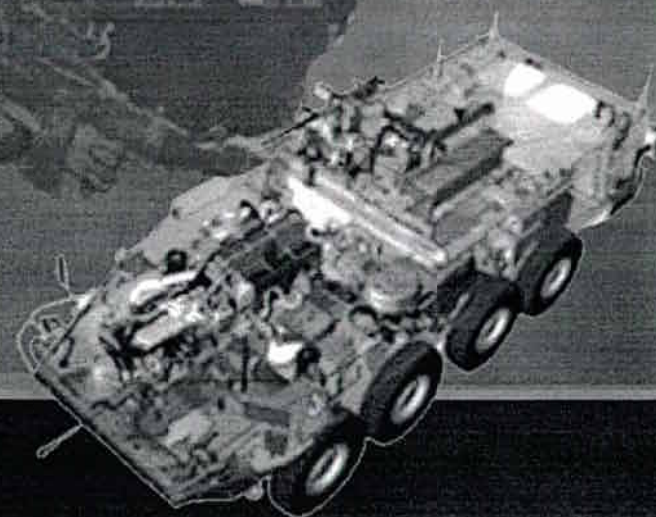
[jasterj@tacom.army.mil](mailto:jasterj@tacom.army.mil)



FOR A



SUPERIOR ARMY



# TARDEC

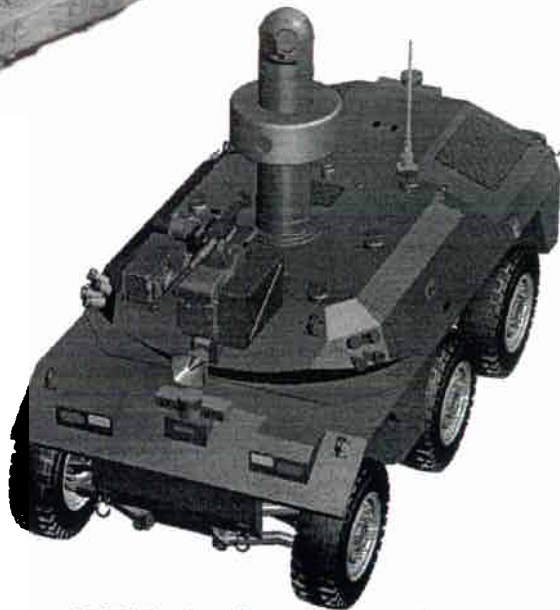
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# ARV Robotic Technologies (ART) ATO



ART Technology Surrogate

## Schedule

MILESTONE (FY)	04	05	06	07	08
• Develop ARV Technology					
• Develop UGV M&S Suite					
• Analyze UGV Vulnerabilities and develop countermeasures					
• System Integration and Test					
• Conduct Warfighter Experiments and Evaluations					

## Purpose:

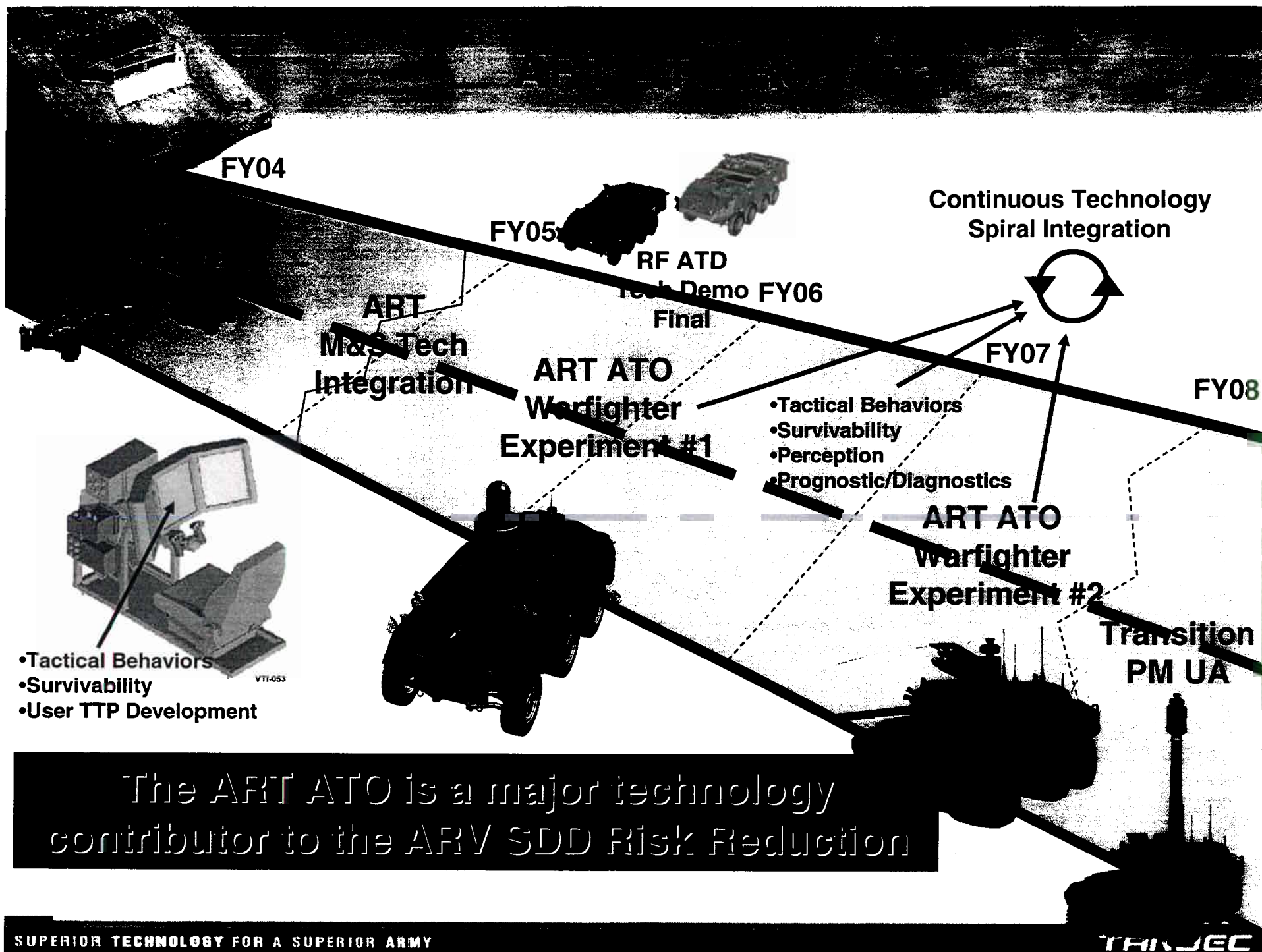
Advance the state of the art in unmanned platform technologies achieve FCS ORD capabilities of ARV systems and ARV teams.

## Product:

- Enhanced Semi-Autonomous Mobility Suite
- Integrated Tactical/Mission Behavior System
- Survivability Technology/Devices/Payload
  - Above products will be integrated into a surrogate ARV system demonstrators with additional Mission Modules to support User Experiments
- UGV Modeling and Simulation Suite
  - Improved models for sensors, platforms, behaviors
  - Models are MATREX compatible

## Payoff:

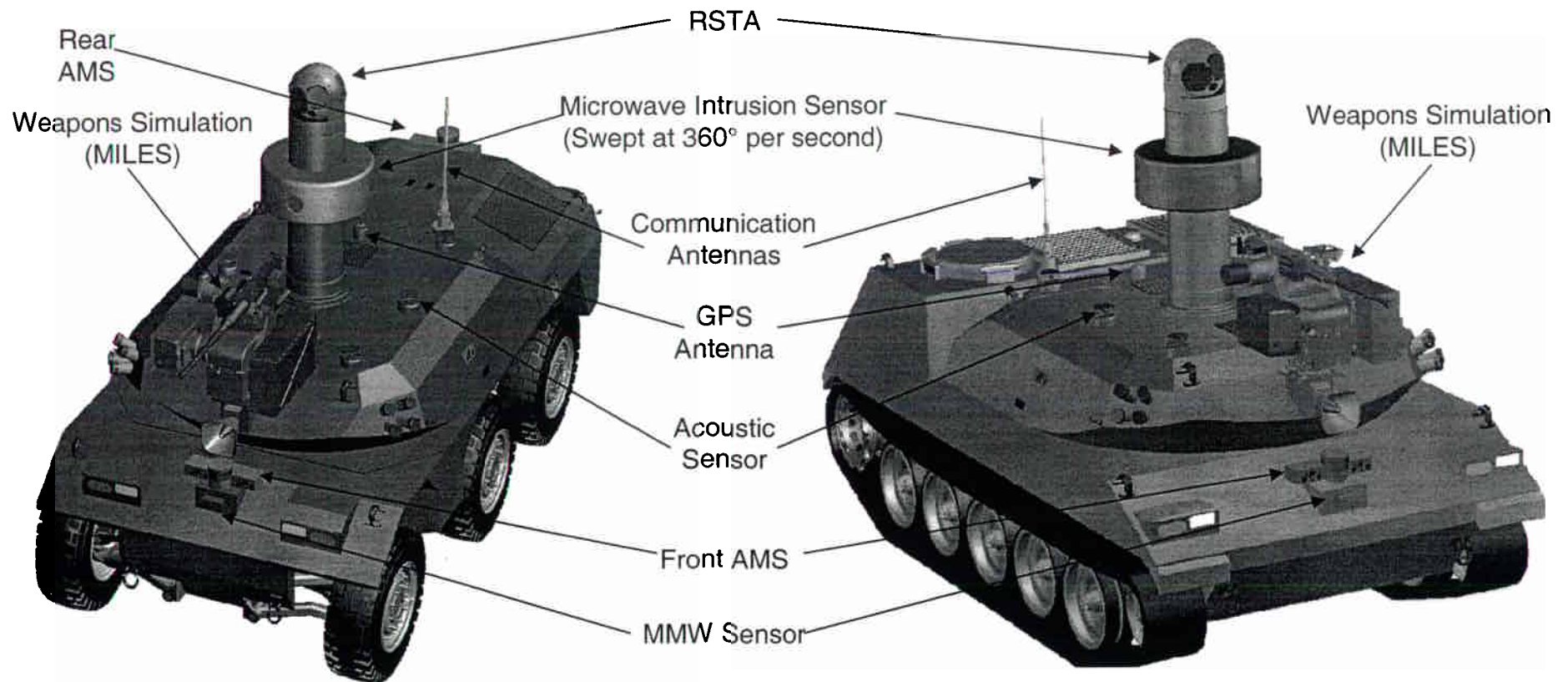
- Reduce soldier burden/interaction
- Improved semi-autonomous operation in adverse weather and urban/complex terrain.
- Tactical behavior incorporated into semi-autonomous maneuver.
- Reduced vulnerability to enemy tampering.
- Increased soldier survivability using unmanned systems.



## ART Solution : Mechanical

Have both tracked and wheeled options to follow ARV decision

- Based off of commercial platforms (GPV 6X6, M113)

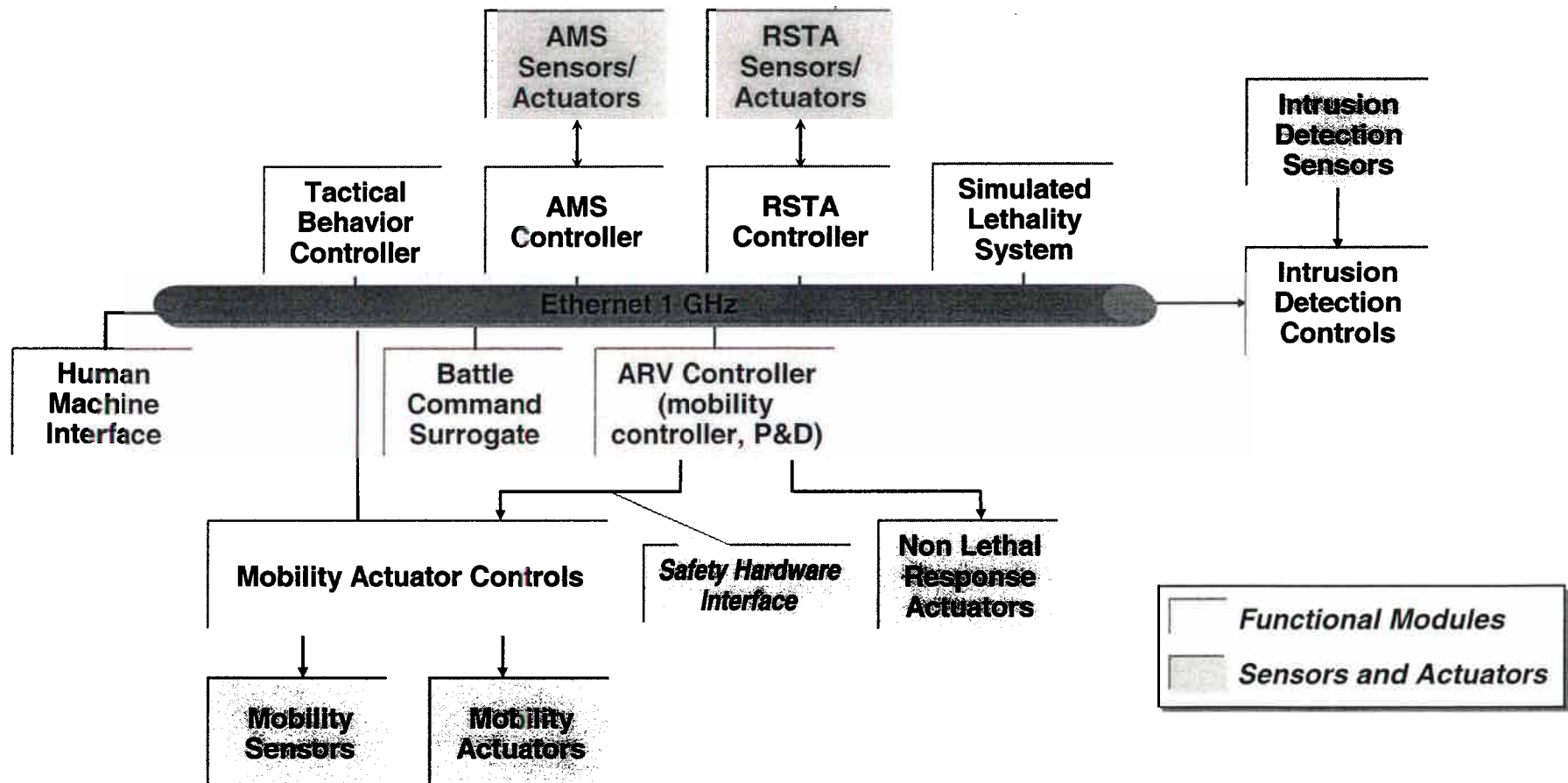




# ART Solution : Vetronics

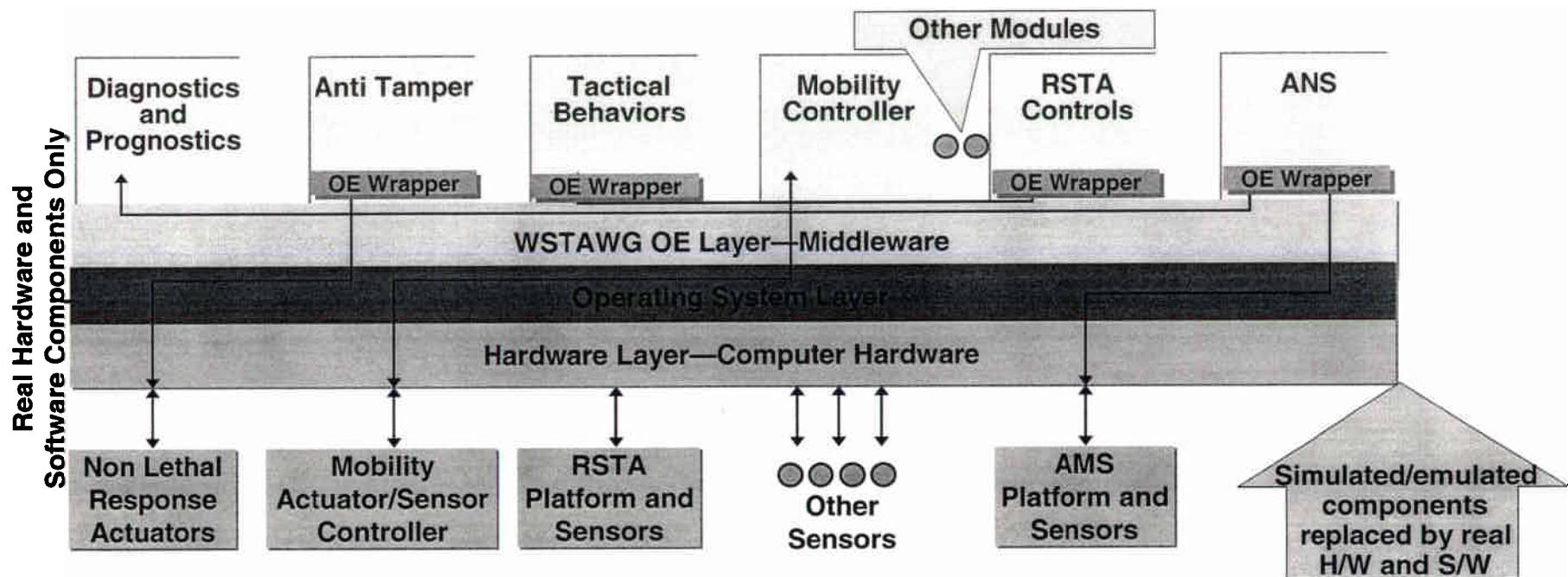
## Open Vetronics architecture

- Ethernet backbone permits addition of new components



# ART Solution : Software

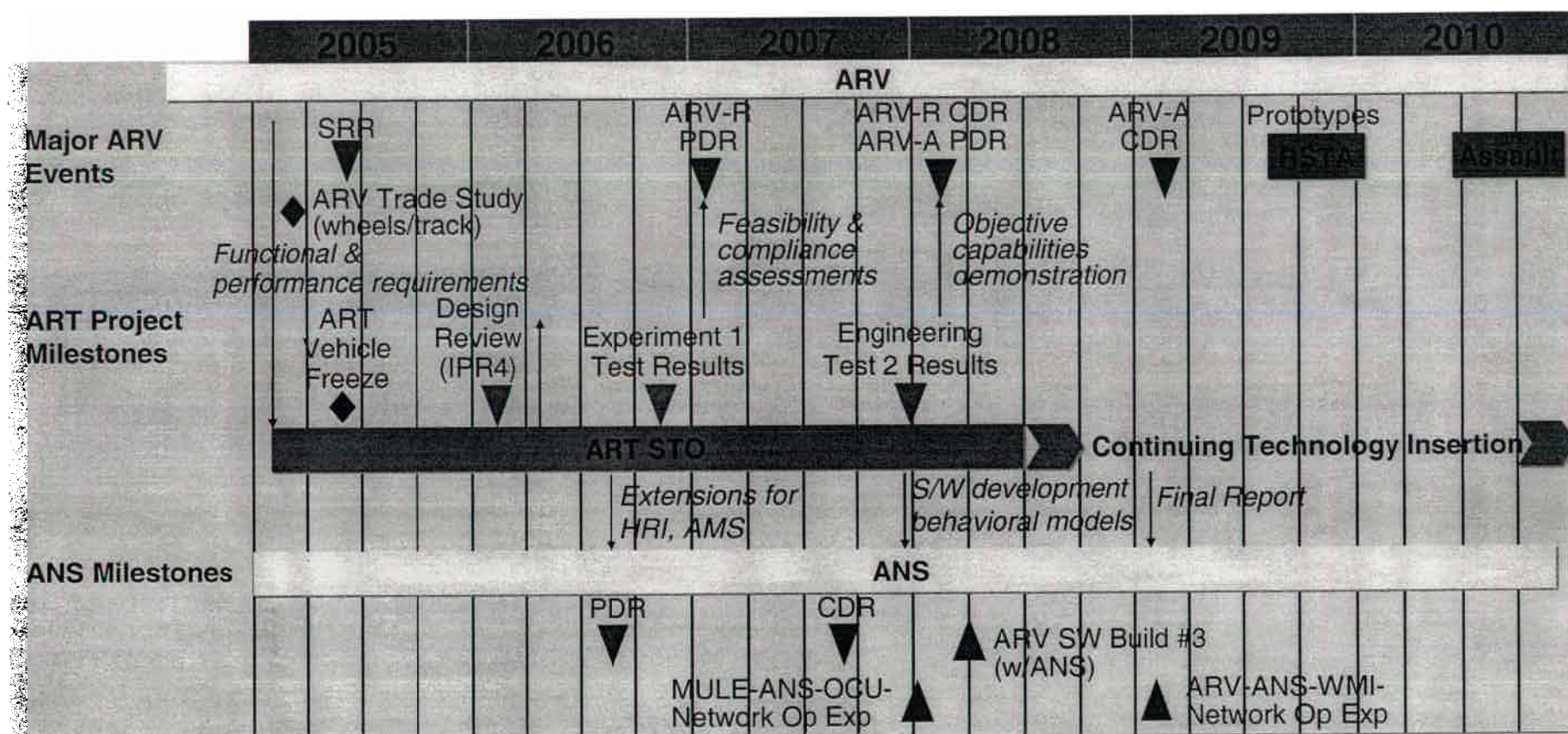
Layered software architecture approach uses middleware to reduce integration risk





# Program Plan

- Aligned ART experiments feed ARV and ANS

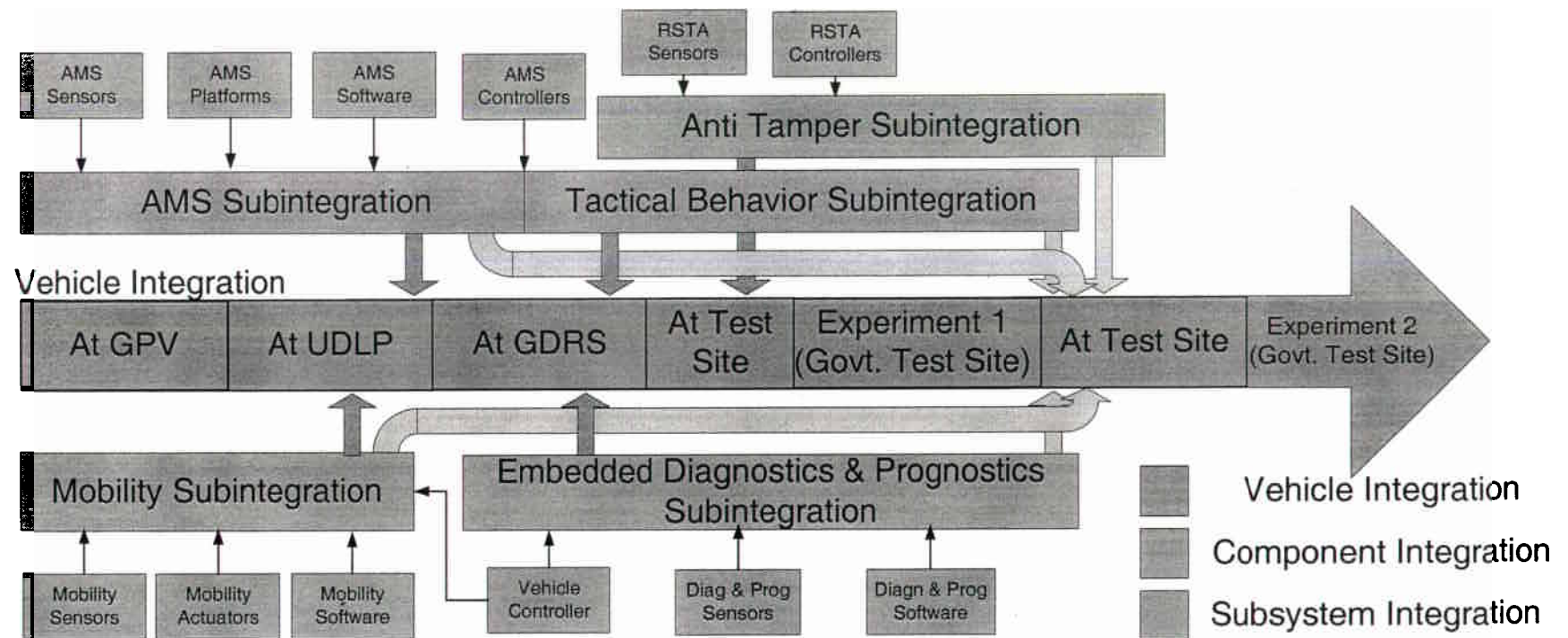




# Integration Approach

Multi-site plan accommodates concurrent integration complexities

- Time-phased integration strategy addresses availability limitations



# Tactical Behavior Development

UA O&O,  
system  
books,  
battle books,  
robotic TTPs,  
UA IPs, design  
reference  
mission, etc.

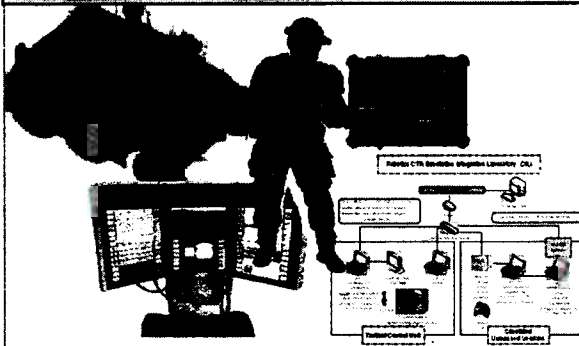
**Partner with TRADOC /  
UAMBL to understand  
"how to fight"**

**Refine FCS ARV  
O&O Concepts**

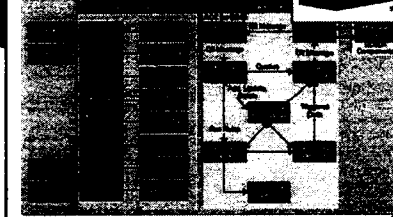
**Identify and specify**

## Iterative Tactical Behavior Synthesis Process

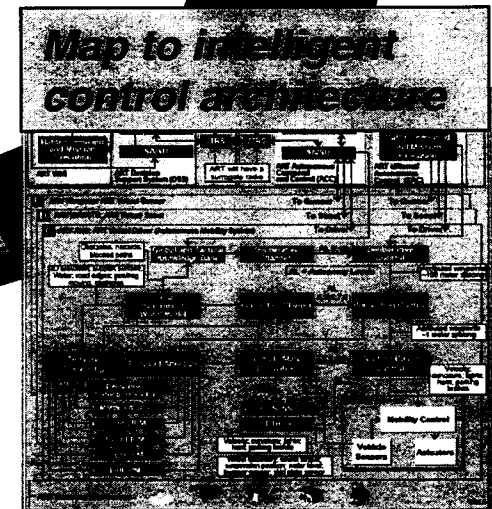
**Evaluate and assess in SIL  
and field experiments**



**Implement in Vetronic  
hardware/ software  
components**



**Map to intelligent  
control architecture**

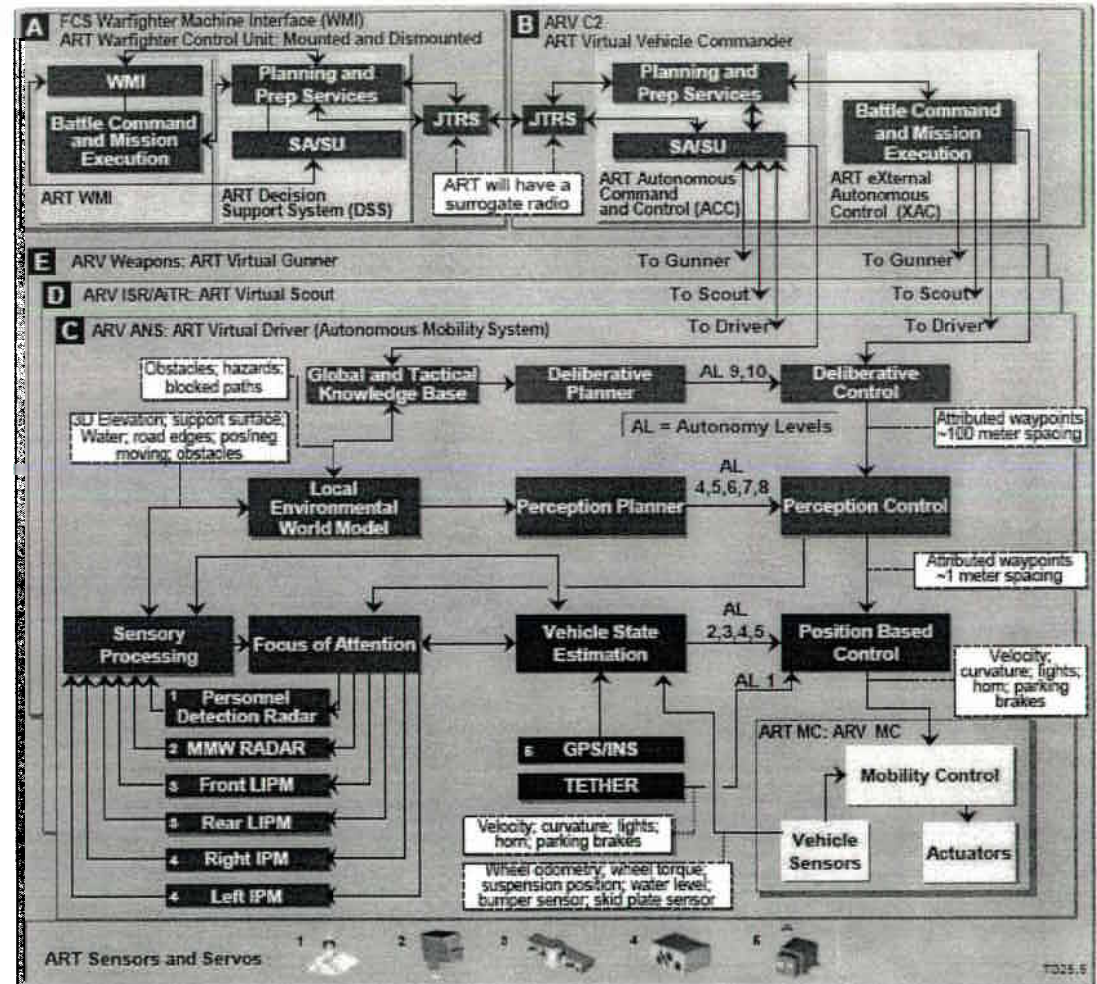




# Intelligent Control Architecture

Manages implementation of complex behaviors

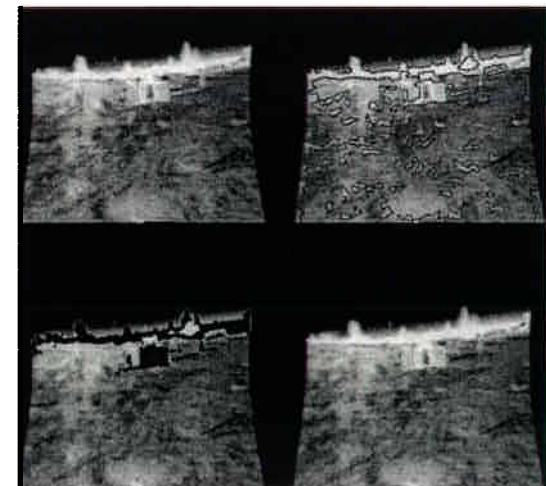
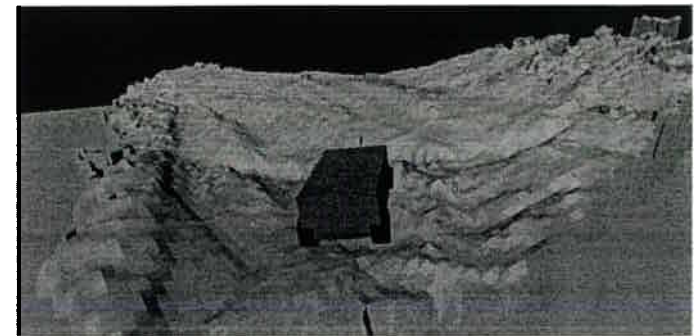
- Mirrors ARV/ANS architecture
- Architecture based on 4D/RCS reference model
- JAUS-compliant
- Proven implementation: Sensor/servo to commander



# Advancing Negative Obstacle Detection

## Modeling & Simulation

- Sensor placement
- Mobility/terrain interaction
- **High resolution sensors**
  - LADAR, Vis/NIR, LWIR
  - Pixel-level fusion
  - Advanced preprocessing
- **Accumulated world model**
  - A-priori terrain elevation
  - Temporal integration
  - Support surface tracking





# Opaque Sensor Perception Advancements

## Multi-sensor phenomenology

Condition	See-Through	Degraded
Dust, Smoke, Fog	MMW, LWIR (except fog)	LADAR, Vis/NIR, FPR LWIR (fog)
Moderate Vegetation	LADAR, LWIR, FPR	Vis/NIR, MMW
Heavy Vegetation	FPR	LADAR, Vis/NIR, MMW, LWIR

- **Algorithms for detection and planning**

- Support surface determination
- Density calculation
- Multi-

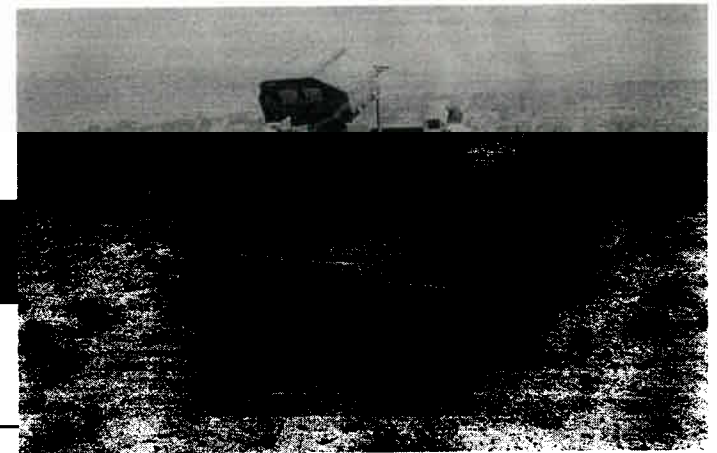
*Two-pronged approach focuses on  
sensor and algorithm improvements.*





# Perception Advancement in All Weather Conditions

- Address operations in degraded LADAR environments through multi-spectral sensors....



Daytime	LADAR, Vis/NIR, LWIR, MMW, FPR	--
Night / Low-Light	LADAR, LWIR, MMW, FPR	Vis/NIR
Smoke / Dust	LWIR, MMW	LADAR, Vis/NIR, FPR
Dense Fog	MMW	LADAR, Vis/NIR, LWIR, FPR
Rain / Snow	MMW	LADAR, Vis/NIR, LWIR, FPR

...and improved algorithms

- Adjustable sensor weights
- Terrain adaptive velocity
- Data registration
- Sensor fusion

*Focused on graceful degradation of vehicle performance.*



# Anti-Tamper Approach

Multi-modal detection and response for layered standoff

- Integrates and augments state-of-the-art algorithms

## Layered Detection

### RSTA sensors

- Impulses (direct fire) detection and localization
- Vehicular detection localization and tracking
- 360° out to ~3km

### Autonomous Mobility Sensors

- LADAR 360° out to 50m
- Imaging 360° out to 100m
- Mounted/dismounted mover detection and tracking

### Personnel Detection RADAR

- 360° out to 100m
- Detection and tracking

## Layered Response

### Initial Warnings

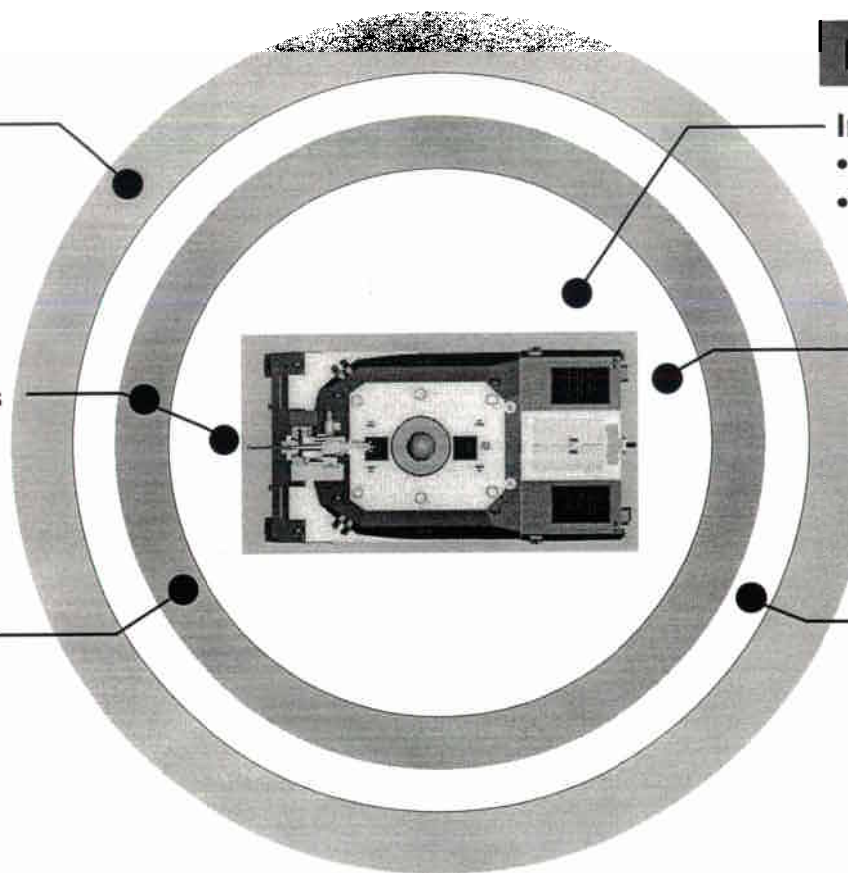
- Warning speaker
- Turret motion

### Particle Spray

- 4x90° non-turreted
- Concentrated field of 250 sting balls
- Countermeasure out to 10-15m

### High Intensity Search Light

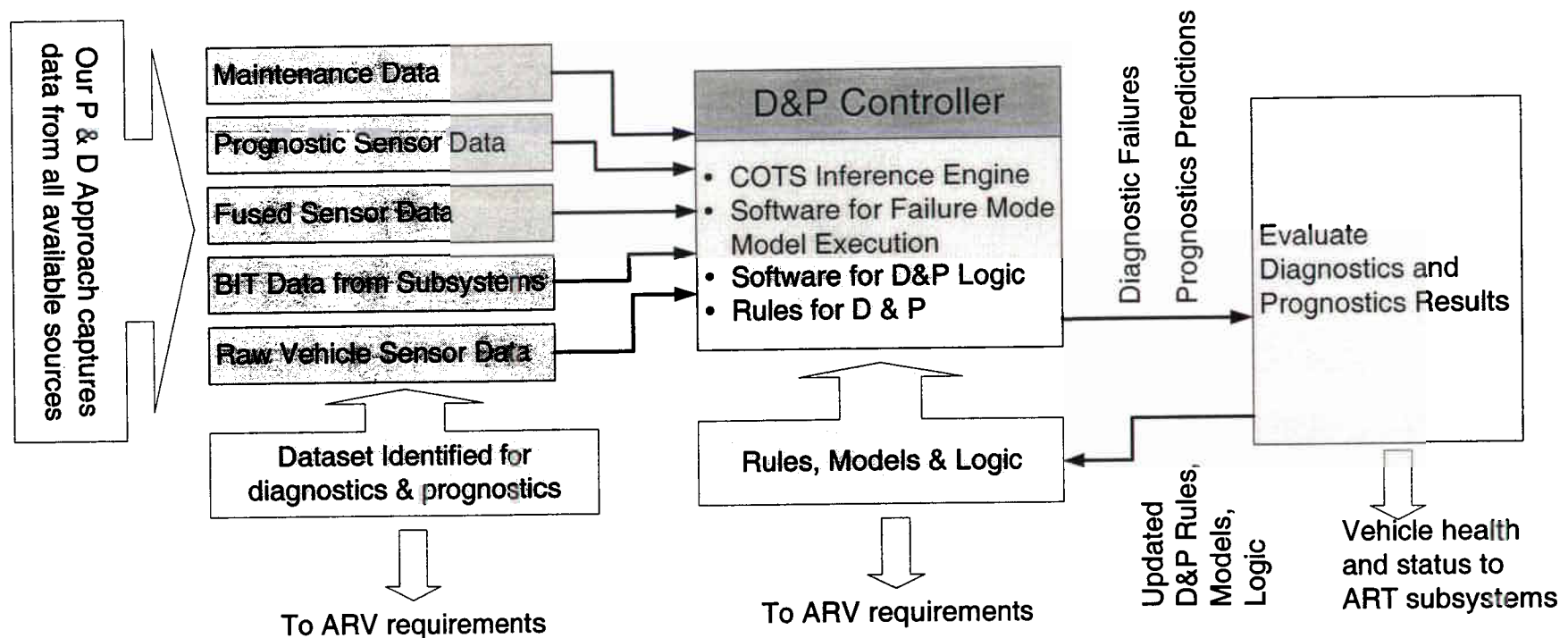
- Turreted 75w Xenon arc lamp with strobe
- 6m candle power
- Variable beam 2° to 40°
- Range of 1.5 miles



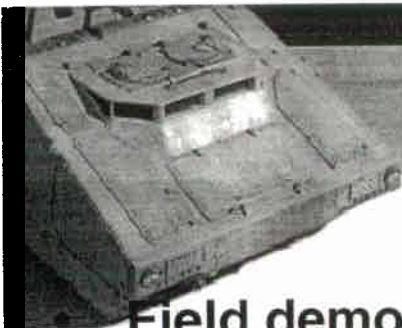
# Prognostics and Diagnostics Architecture

Continuously update our knowledge base

- Will take advantage of the fused sensor data on the ART platform
- Use a COTS based inference engine
- Architecture consistent with FCS ARV







## Experiment 1 Capabilities - Sept 2006

### Field demonstrations utilizing ART vehicle as an ARV surrogate

- Includes both user testing (with users from UAMBL) as well as engineering tests
- **AMS**
  - Day-night operation
  - Improved negative obstacles
- **Tactical Behaviors**
  - All move modes in open terrain
  - Cooperative movement with other vehicles
  - Occupy battlefield positions in open terrain
- **Anti-tamper**
  - Detection
  - Mobility response
- **Prognostics and Diagnostics**
  - Keep vehicle safe
- **Demonstrate ART meets final mobility requirements**
- **Initial RSTA capability**
- **Interface with HRI**



## Experiment 2 Capabilities - March 08

### Field demonstrations utilizing ART vehicle as an ARV surrogate

- Includes both user testing (with users from UAMBL) as well as engineering tests
- **AMS**
  - All weather operation
  - Opaque sensors
- **Tactical Behaviors**
  - Tactical movement in MOUT environment
  - Cooperative engagements with vehicles and dismounts
  - Occupy MOUT positions
  - Stealthy movement
  - React to local threat
  - React to loss of mission capability
- **Anti-tamper**
  - Detection
  - Deterrence response
- **Prognostics**
  - Selected ARV use cases
- **Full RSTA functionality**
- **Simulated lethality component**



# Transition, Maturation & Risk Mitigation Efforts for ARV

## • Anti-tamper Techniques

- Anti-tamper/ANS fusion
- Includes 360 situational awareness
- Includes behaviors and processes

## • Survivability Technologies

- UGV unique

## • Tactical behaviors/adaptive tactical reasoning

- System level mobility
- Dynamic vehicle response

## • Embedded Prognostics and Diagnostics

- UGV unique

